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THE HABITS OF *NECTURUS MACULOSUS*¹

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NECTURUS although widely distributed throughout eastern and middle North America, is found most abundantly in the rivers tributary to the Great Lakes and in the inland streams and small lakes of the adjoining States. Upon the study of the lake species (*Necturus maculosus* Rafinesque) the following notes are based.

The many names under which *Necturus* has been described lead to such confusion that some of those most frequently met are here given: *Necturus maculatus*, *Necturus maculosus*, *Necturus lateralis*, *Menobranchnus lateralis*, *Menobranchnus tetradactylus*, *Menobranchnus sayi*, *Menobranchnus lacepedii*, *Menobranchnus hyemalis*, *Phanerobranchnus tetradactylus*, *Phanerobranchnus lacepedii*, *Triton lateralis*, *Proteus maculatus*, *Siredon hyemalis*, *Siren lacertina*. It is known by fishermen and others unacquainted with scientific nomenclature by various names such as: *Proteus* of the Lakes, *Proteus* of the Alleghany River, *Siren* of Barton, mud-puppy, water-dog, water-lizard, fish-lizard, etc.

Size.—According to the writer's observations the adults vary considerably in size, ranging from twelve to eighteen inches. This is based upon an extended series of measurements of individuals taken from different localities and comprising not only the females taken from their nests in the spring, but also both males and females taken in the autumn. It is thus evident that the writer cannot agree with David Starr Jordan ('99, p. 175) and other eminent systematists that *Necturus* attains a length of 24 inches. In order to ascertain upon what observations these

¹ Rafinesque, in 1818, described this form under the name *Sirena maculosa* (*Amer. Monthly Mag. and Crit. Review*, vol. 4, 1818, p. 41). In 1819, the name *Necturus maculatus* was given (*Journ. de Physique*, vol. 88, 1819, p. 418). In 1820 the specific name *maculosus* was restored (*Annals of Nature or Annual Synopsis of new Genera and Species of Animals, Plants . . . discovered in North America. First Annual Number*, 1820. Transylvania University, March 1, 1820. Lexington, Ky.).

statements are based, the literature has been carefully searched.

If we turn to the earliest description, given by Schneider (1799, p. 50) we read: "Corpus ultra 8 pollices longum." This measurement was given for the specimen which he found in Hellwig's cabinet at Braunschweig and which Hellwig had obtained from Lake Champlain. The specimen described by Lacépède ('07, p. 230) was obtained by M. Rodrigues and placed in the Natural History Museum but its original source was unknown. The specimen measured 15 cm.

Mitchell ('21) in 1821 received a specimen from Major Delafield taken from Lake St. Clair. In a descriptive letter written to Professor Configliacchi of Pavia we read the following: "He grows, as I am informed, frequently to the length of two feet. The present specimen is not more than one half that length, one of the smaller having been selected for the greater ease of transportation."

A length of two feet is here mentioned for the first time, and as Harlan ('35, p. 164) has already pointed out, this mistake was due to the fact that *Necturus* and *Cryptobranchus* were confused by Mitchell. In a letter written to Charles de Schreiber in 1823 Mitchell ('21) even speaks of *Necturus* as the creature "which the white fishermen have called by the vulgar name of Hell-bender and the Indians Tweeg." It is not difficult to understand how such an error might have occurred since certain naturalists (Daudin Lacépède, Barton) had considered *Necturus* as the larval form of *Cryptobranchus*.

Even Cuvier ('29) writes: "L'espèce la plus connue (*Menobranchus*) vit dans les lacs de l'America septentrionale, et devient fort grande; atteint dit on, deux et trois pieds." Since this time the error has been repeatedly copied.

Coloration.—The color of the adult is so variable that a description does little more than emphasize this fact; indeed the writer has been so forcibly impressed with this variability that it has led to the surmise that *Necturus* possesses the ability, more or less common to other *Amphibia*, of changing its color through its control of the black chromatophores. The animal usually appears a dark ashy brown above, with more or less irregular mottling; below it is more evenly colored and of an ashy flesh

tint. The mottling is due to the presence of large irregular dark areas which are surrounded by a pale yellow margin. Often these spots coalesce to form larger areas or bands. In the younger animals there is frequently a dark band extending from the nostril to the eye, from the eye to the anterior margin of the gills, and from the posterior margin of the gills backward along the side of the body. In some cases the upper surface presents no large areas but is more uniform, and the chromatophores and lipochromes are so distributed that the surface presents a granular appearance. The ventral surface of the body frequently becomes lighter toward the median line and in some a sharply defined *linea alba* is present. The lower part of the head and tail are frequently dotted with small clusters of lipochromes.

In short, the contrast of black and yellow may in some appear vivid, in others subdued and again disappear almost entirely. It is probable that these variations in color are responsible for a number of specific names. As an instance I might state that some years ago Dr. Garnier ('88) described a small *Necturus*, taken from the Maitland and Lucknow Rivers in Ontario, to which he gave the name *Menobranchus lateralis*, var. *latastei*. "The colouration above was black, the abdomen sooty and the gular fold white."

During the summer of 1904 the writer was fortunate enough to secure two young animals which measured about 4 and 6 inches respectively. The smaller corresponds closely to the description given by Dr. Garnier and there is every reason for believing that the animal in question is the young of *Necturus maculosus*. The older of the two presents the general coloration of the adult. That *Necturus* should undergo such striking changes in color may appear remarkable to one who has not studied the early stages but when one has followed the changes in color patterns during growth he finds that they are no less striking and remarkable than in the birds.

Habitat.—The environment to which they are best adapted is not known. In spring and summer excepting the time of egg-laying they are most frequently observed in quiet waters from four to eight feet deep where a clean sandy bottom is fairly well covered by vegetation. In the autumn they are found in pairs

or small groups. From this fact and others to be recorded later it is inferred that this is the mating season.

At times they seem to congregate in large numbers. Milner ('74, p. 62) states that "Mr. George Clark of Ecorse, Mich., had a minnow-seine fitted to the bag of a sweep-net, and at one haul took two thousand of the 'water-lizards.' Estimating the extent that the net had passed over, he calculated the average number of 'lizards,' to each square rod, to be four." Milner again states that "a fisherman at Evanston, Ill., a few years ago had nine hundred hooks set in the lake, and in one day took from these five hundred lizards."

Holbrook says that "they are seldom taken except in the months of April and May." Kneeland states that "they are rarely if ever seen except during the winter." The writer has repeatedly taken them through the ice on set lines during the months of January and February. Reese also reports having taken them through the ice in February. While there are no records showing that they are taken in all the winter months there is but little doubt that they are more or less active throughout the winter, a fact which indicates the absence of a period of hibernation.

Necturus moves from place to place at night and rests quietly beneath boards, logs, or stones during the day. In aquaria they avoid the sunlight, and retire if possible to a shaded portion and always seek concealment. Their movement in the water is slow and is effected by walking, in which act the diagonally opposite legs move in unison. When disturbed they move with celerity through a vigorous lateral motion of the broad and powerful tail, with the feet closely applied to the body and motionless. They never swim long distances, at most a few yards, then seek concealment either in the mud or beneath some object.

One is rarely fortunate enough to get a glimpse of them during the day; they seem to be extremely sensitive and disappear at the slightest disturbance of the water, such as that caused by the approach of a boat. If they are undisturbed, one usually sees the head protruding from beneath the concealing object. The animal thus presents a curious appearance with its ruby gills moving gracefully to and fro. When they are disturbed the gills change from their bright red to a dusky color and are at once drawn down tightly against the neck.

When these animals are retained in aquaria they are frequently observed to thrust their snouts above the water, open the mouth widely, and then return to the bottom where they soon expel the air both through the gill slits and from the mouth. It would thus seem that while the branchiæ are the chief means of respiration the lungs play considerable part. Kneeland ('59) made some very interesting observations on this point which are here quoted. "He put two of these reptiles into an aquarium with half a dozen minnows, varying in size from two to three inches. The fish were frequently seen nibbling at the expanded gills of the reptiles, which as often suddenly darted from their ordinary state of repose, attempting to seize the fish, which they never succeeded in doing. In about ten days the menobranchs had nothing left of the gills but the almost bare cartilaginous supports, with only here and there a branchial fringe. The fish were then taken out, and the branchial fringes began to grow again, and in the course of six months had regained about half their normal size. He had watched these reptiles for two summers, and no similar falling of the gills ever took place, so that it appears in the present instance that the fish actually eat them off, their loss being a pathological and not a natural phenomenon. In either case this fact seems interesting from a physiological point of view, as bearing upon the respiratory organs of these reptiles. He had ascertained experimentally that they survive out of water about four hours, showing that their pulmonary sacs, or lungs, are not alone sufficient for the maintenance of respiration. In the present instance, though their pulmonary sacs were the principal respiratory organs, the animals did not apparently suffer. . . .

"The question arises, why are these lungs apparently sufficient for respiration in the water and not in the air, though the respired element be in both cases the same? As there is no evidence of internal gills, the reason must be that in the air the branchial tufts from dryness are unfit for circulating the blood, the complementary respiration of the skin, so important in reptiles, cannot be carried on—the pulmonary sacs alone are insufficient for the aëration of the blood, and the animal dies. In the water, however, even though the branchiæ, as in this case be useless, the cutaneous respiration is unimpeded and with the pulmonary

is sufficient for the purification of the blood. This fact shows the importance of the cutaneous respiration and the insufficiency of the pulmonary."

Food.—Concerning their natural food little is known beyond the fact that dissections of the alimentary tract reveal the presence of small crustaceans, insect larvæ, and occasionally a small fish. Harlan ('35) and James ('23) both record having found earthworms in the alimentary tract. Kneeland ('58) says: "They seize living worms eagerly and suck them down, if small, with a single sudden swallow; if the worm be large, it is swallowed by repeated suction, the teeth preventing its escape; the act of suction may be seen by the movements of the impurities in the water, as it is drawn in and afterwards expelled. They often miss the worm; sometimes it may be too far off, but at others so close to them that it seems that their vision must be imperfect. They will not eat a dead worm unless they have been kept without food for a considerable time."

A very curious performance was witnessed by Kneeland and reported by the secretary of the Boston Society of Natural History as follows: "A number of *Necturi* had been without food for five months when four living minnows were placed in the aquarium, three of the four minnows were swallowed before the expiration of fifteen minutes, and among them the largest. After they had swallowed them, they seemed very uneasy, moving the bones of the head and jaws, and contorting their bodies in various ways, as if they did not feel quite easy in their stomachs; however they at last became quiet, but at the end of twenty hours they became uncommonly active, and the three fish were regurgitated with the scales off, the eyes out, and the entrails of the smallest gone; they were perfectly white, and looked like ghosts of fish. It was either diet too gross for their delicate and weakened stomachs, or else not sufficiently comminuted for the action of their gastric juice." Garnier says that they eat small living fish and crayfish by preference, and do not readily take meat in captivity.

Montgomery states that "from observations of the *Menobranchus* in an aquarium plentifully stocked with molluscs, such as *Physidæ*, *Limnæans*, *Paludinæ*, *Planorbes*, *Anodonts*, etc., as

well as crustaceans I am not warranted in asserting that it feeds on anything other than true fishes."

Milner quotes Clark as stating that "those taken at Ecorse, Mich., were so gorged with white-fish spawn that when they were thrown on shore, hundreds of eggs would fly out of their mouths."

The writer has tried to feed them with various kinds of food. *Necturus* will readily eat living earthworms but will pay no attention to dead ones. Pieces of liver which are held in forceps and moved gently through the water in close proximity to the snout they seize and devour. But the most satisfactory food is small minnows which at intervals are placed in the aquaria. The movements of the minnows seem to excite the animals whose heads are soon seen protruding from beneath the concealing objects. When the minnow comes in close proximity there is a flash-like movement toward the minnow which in turn either escapes or is swallowed. The writer has observed repeated failures to catch the minnow, but the persistence of the animal is remarkable and it sooner or later succeeds.

From the fact that whenever the water is disturbed in the vicinity of the snout they snap viciously one is led to infer that in taking food they rely almost entirely upon the tactile sense.

Necturus is much dreaded by the ordinary fishermen who regard them as poisonous as do also the Indians (Durkee). According to Gibbes ('53) the negroes are terrified by its presence. He says that "the piggin or wooden vessel, in which an animal was placed after its capture, was destroyed by the negro to whom it belonged, who was resolved never to carry food in it or eat out of it again." Notwithstanding this popular superstition the animal is perfectly harmless and may be handled at pleasure. Its flesh is white and said to be very palatable by Wilder ('74) who writes as follows: "In preparing a paper upon their anatomy and embryology, Dr. W. S. Barnard and myself have had occasion to use them in numbers; and a single fisherman, who sets many hooks for fish has brought us a hundred during the past month (March); he, and all others, apparently regard them as poisonous, and are rather averse to touching them; so far is this from the case, that they are absolutely harmless in every way: and on the 5th Dr. Barnard and myself ate one which was cooked,

and found it excellent: it is our intention to recommend it as food, but not until our investigations are complete."

Their great tenacity of life is a matter of frequent comment. They seem to be able to live for months without food. They have been left for three or four hours out of water and are then easily revived. After severe mutilations they recover, but notwithstanding this great vitality they seem to fall easy victims of a fungus which has not as yet been determined specifically. Mr. Browne (Milner, '74) of Grand Haven, Michigan, states that "some years ago, an epidemic seemed to prevail among the *Meno-**branchi* in Grand River, in the month of June, and that their carcasses were washed ashore by hundreds, so that they lined the banks of the river and the mill-men were obliged to throw the bodies off into the current, to be carried down stream to prevent the offensive stench that was wafted into the mills from the decaying remains."

Casting of Epidermis.—Kneeland ('57) states that *Necturus* sheds its epidermis in the winter. "They shed their skins at this season; I have had several with the old skin hanging to the new in shreds and patches, which are washed off by the water in two or three days, leaving the colors of the new skin very bright; the edges of the tail are then so thin and transparent that the network of blood vessels can be seen with the naked eye."

While endeavoring to obtain a photograph of *Necturus* on February 9, 1897, Mr. A. H. Cole, one of my students, observed the animal cast its epidermis. His notes read as follows: "The epidermis as a thin layer appeared to have loosened from the entire surface of the body, appearing frosty-white with bubbles of air. The loosened epidermis was split along the mid-dorsal line, its free edges floating upward in ragged streamers. On the following day none of the epidermis remained excepting glove-like portions which were yet attached to the feet; these portions were not cast until two days later."

Breeding Habits.—Although more than a century has elapsed since *Necturus* became an object of special study on the part of both American and European naturalists, no one seemed fortunate enough to obtain embryological material until Professor

Charles O. Whitman some eighteen years ago discovered the nests and obtained a complete series of developmental stages.

Those who sought the embryological material were forced to enter an unexplored field. No one felt certain that he had even found the adult animal, since the error of Mitchell, that the adult measured two feet, had been and is yet, copied by the leading systematists. Moreover, Barton (Gray, '57, p. 61) held that the animal was the larval form of *Cryptobranchus*. Cope ('66) expressed the opinion that it was a larval *Sperlerpes* and changed in the same manner as the *Siredon* to an *Amblystoma*. Baird ('50) suggested that it might be the unmetamorphosed form of some great salamander as yet unknown. If the above were true it then remained to be determined whether the animal bred in the larval or the adult condition, or in both. All these possibilities demanded careful consideration.

Again it was not known whether they were purely aquatic or whether they came frequently on land, as described by Smith ('32), DeKay ('42), and others. When this question was answered others arose, and foremost among these was the time of breeding. Concerning this period there were numerous conjectures. Kneeland ('57) states that the animals were taken in abundance near the shore during the winter months. "The reason why they approach the shore at this season may be on account of this change in skin, and possibly for breeding purposes. About once a week they pass from the anus a gelatinous mass, about the size of a pea, of a whitish color, I thought this might be possibly an egg, but the envelope soon becomes soft in water, and its contents are lengthened out into a somewhat convoluted form."

Holbrook ('42) observes that they are "seldom taken except in the months of April and May which is their spawning season. Their eggs are about the size of peas and as many as one hundred and fifty have been counted in a single female."

Milner ('74) states that a "full series was this season ('73) collected from the Detroit River, from the length of one and one fourth inches to thirteen inches. Later, about the middle of the month of July, Mr. George Clark collected a quantity of their eggs, proving this month to be the spawning season of the animal."

Spring, summer, and winter were each regarded as the breeding season and, so far as the observations were concerned, with equal degrees of probability.

Thus there was little to be gathered from the observations previously made. The only reliable data were to be obtained through a systematic examination of the ovarian eggs at different seasons of the year. Even when this tedious work had been carried out and clews obtained as to the egg-laying period, other and greater difficulties arose. The Great Lakes and their tributary streams in which *Necturus* had been reported most abundant were usually so clouded by muddy water that search for eggs was futile. Localities must be found where the animals were plentiful and where the water remained clear. The small inland lakes of eastern Wisconsin seemed best to fulfil these conditions. Again, no one knew or had even suggested where the animals deposited their eggs, whether in deep or shallow water, whether they were laid in masses in open places like those of *Amblystoma*, or scattered in strings like those of the toad, or laid singly and concealed among the leaves and branches of aquatic plants like those of the newt.

The knowledge of the egg-laying habits of other Amphibia gave no clue, but nevertheless the work was continued and after years of persistent and patient effort Professor Whitman finally discovered the nests and eggs of *Necturus*. Only those who have for years been baffled in their attempts to obtain the embryological material of other North American Urodeles, such as the *Siren*, *Amphiuma*, and *Cryptobranchus* can properly appreciate the enormity of the task.

Through the kindness of Professor Whitman the writer first obtained a knowledge of the habits and breeding places of *Necturus*, and each summer for the past eight years has made observations on the habits of these animals in their natural environment.

Egg-laying.—The time of egg-laying varies in different lakes, depending upon the time when the temperature of the water reaches a certain degree. In the larger, deeper lakes with bold shores this is much later than in those possessing wide shoals. Again, in the individual lakes the time is dependent upon the same conditions. The eggs are first deposited in those localities where the water is shallow and exposed for the greater part of the day

to the sun. The period of egg-laying usually covers two or three weeks. There is no foundation whatever for the statement made by Hans Virchow¹ that the animals deposit their eggs so to speak at the same hour.

According to Professor Whitman's and my own experience the best time for collecting is during the middle and latter parts of the month of May. The writer has collected eggs as early as May 3, and as late as June 5, but these extremes mark the beginning and closing of the early and late seasons.

Preparatory to egg-laying, *Necturus* seeks the sandy shoals of the lakes or streams. They seem to prefer those localities where the bottom is strewn with numerous logs and boards. It is more than probable that the animals seek these grounds at night since they are rarely if ever seen moving about during the day.

During the day they lie quietly concealed beneath the various objects and one not familiar with their habits would rarely if ever detect their presence. If one desires to see the animals in their natural positions he must approach with much care and he may perchance be rewarded by seeing the head of one protruding. If, however, the jar of the boat or the scraping of an oar has caused them to hide, he must overturn the concealing object. If this is done with great care the animal is occasionally undisturbed and lies for some time motionless, then begins to crawl slowly about. If, however, the disturbance be violent it darts away and conceals itself beneath some other object.

The nest of *Necturus*, if indeed, such it may be called, is, as has been said, always carefully concealed beneath some object and consists of nothing more than a slight excavation in the sand with a narrow opening through which the animal's head protrudes; the nest is thus perfectly guarded against the attacks of enemies. The objects beneath which the nests are most frequently found are clean logs or boards which lie partially imbedded in

¹ *Sitzb. Ges. naturf. Freunde zu Berlin*, 1894, p. 37: "Necturus kommt in den zahlreichen Seen im südlichen Wisconsin häufig vor und auch an anderen Stellen der Vereinigten Staaten. Die Laichzeit ist nach mündlichen Angaben der Brüder Meyer Mitte Mai, im Jahre 1893 fiel sie auf den 22. Mai, d. h. später wie gewöhnlich; sie variirt nach dem Wasserstande. Die Thiere legen nicht zu verschiedenen Zeiten ab, sondern angeblich zu gleicher Zeit, sozusagen auf dieselbe Stunde."

the sand. The writer has also found them beneath pieces of tin, canvas, and even an old hat.

The depth of the water in which these nests are found, is variable. The writer has found nests covered by only four inches of water, again a nest was found beneath a board at a depth of ten feet, but these are unusual conditions. The majority of nests are found at a depth of from two to four feet. The nests are often found in close proximity to one another; and it is not at all exceptional to find several nests on a single board frequently not more than a foot or two apart. In one instance ten nests were taken from a single board not more than twelve feet long.

In order to facilitate the collection of eggs it has been found advantageous to place boards in suitable localities during the early spring months. When the breeding time has come many of these shelters will have been chosen as nesting places.

During egg-laying the males are never found with the females, and where they remain is unknown. In just what manner the female deposits the eggs is also problematic. There are different stories told by those who during recent years have acquired some knowledge of their habits. In some way the female brings her body in such a position that the eggs are deposited on the sheltering object. When the laying is finished the eggs are found scattered over a surface from six to twelve inches in diameter. The eggs are attached singly by the outermost of the three enclosing envelopes and are about a quarter of an inch in diameter, of a pale cream-color, sometimes showing a faint tinge of green.

The period of deposition undoubtedly covers many hours and probably in some instances, days, since in several cases all the eggs were removed from nests and the following day freshly deposited eggs were found. Further proof is found in that the same nests frequently contain eggs in both early and late cleavage stages. This supposition is further confirmed by the fact that some days after the beginning of egg-laying the oviducts yet contain mature eggs.

If one wishes to leave the nest in such a condition that the female will return and continue laying he must exercise great care in replacing the object to which the eggs are attached. If the nest be much disturbed, one will find upon his return for a fresh

supply of eggs, that even those which were left are missing. Several times the writer has found an animal in the nest whose stomach was distended with eggs. The inference, although positive proof is wanting, is that the parent devours her eggs when the nest is much disturbed.

The length of time which intervenes between deposition and the beginning of cleavage has been accurately determined in a single instance in which four eggs were deposited after the animal was placed in the aquarium. These were placed in a hatching dish in which the water was 17° C. In one egg the first cleavage groove appeared in 18 hours, in two at 20 hours, and in one at 23 hours. The time in some cases certainly exceeds 24 hours, since eggs taken from the nest were kept in a hatching dish for this length of time before cleavage began.

LITERATURE

BAIRD, S. F.

- '50. Revision of North American Tailed Batrachia, with Descriptions of New Genera and Species. *Journ. Acad. Nat. Sci. Phila.*, ser. 2, vol. 1, pp. 281-294.

COPE, E. D.

- '66. On the Structures and Distribution of the Genera of the Arciferous Anura. *Journ. Acad. Nat. Sci. Phila.*, ser. 2, vol. 6, pp. 67-112, pl. 25.

CUVIER, G.

- '29. *Le regne animale*. Paris, new ed., vol. 2.

DEKAY, J.

- '42. *Natural History of New York*. Part 3. Albany.

GARNIER, J. H.

- '88. [On a New Species of *Menobrachius (lateralis* var. *latastei*).] *Proc. Can. Inst.*, ser. 3, vol. 5, pp. 218-219.

GIBBES, L. R.

- '53. Description (with Figure) of *Menobrachius punctatus*. *Boston Journ. Nat. Hist.*, vol. 6, pp. 369-373, pl. 13.

GRAY, J. E.

- '57. On the Genus *Necturus* or *Menobbranchus*, with an account of its Skull and Teeth. *Proc. Zool. Soc. London*, vol. 25, pp. 61-64.

HARLAN, R.

- '35. Medical and Physical Researches or Original Memoirs. Philadelphia.

HOLBROOK, J. E.

- '42. North American Herpetology; a Description of the Reptiles inhabiting the United States. Philadelphia, 4to, 5 vols., illus.

JAMES, E.

- '23. Account of an Expedition from Pittsburg to the Rocky Mountains, 1819-20. London, 3 vols.

JORDAN, D. S.

- '99. Manual of Vertebrates of the Northern United States. Chicago, 8th ed.

KNEELAND, S.

- '57. [On a supposed New Species of *Siredon*.] *Proc. Boston Soc. Nat. Hist.*, vol. 6, pp. 152-154.

KNEELAND, S.

- '58. [Habits of *Menobbranchus*.] *Proc. Boston Soc. Nat. Hist.*, vol. 6, pp. 371-373.

KNEELAND, S.

- '59. [On the Breathing Apparatus of the *Menobbranchus*.] *Proc. Boston Soc. Nat. Hist.*, vol. 6, pp. 428-430.

LACÉPÈDE, B. G.

- '07. Sur une espèce de quadrupède ovipare non encore décrite. *Ann. Mus. Hist. Nat. Paris*, vol. 10, pp. 230-233, 1 pl.

MILNER, J. W.

- '74. Report on the Fisheries of the Great Lakes: the Result of Inquiries prosecuted in 1871 and 1872. *Report U. S. Fish Comm.*, 1872-73, pp. 1-75.

MITCHELL, S. L.

- '21. Observations on Several Reptiles of North America, which seem to belong to the Family of *Proteus*, etc. *Amer. Journ. Arts and Sci.*, vol. 7, pp. 63-69.

SCHNEIDER, J. G.

1799. *Historiæ Amphibiorum Naturalis et Litterariæ*. Jena.

SMITH, J.

- '32. [*Necturus* coming out on Land.] *Isis*, p. 1088.

WILDER, B. G.

- '74. *Menobbranchus* Edible. *Amer. Nat.*, vol. 8, p. 438.